ShowerReco update - progress report

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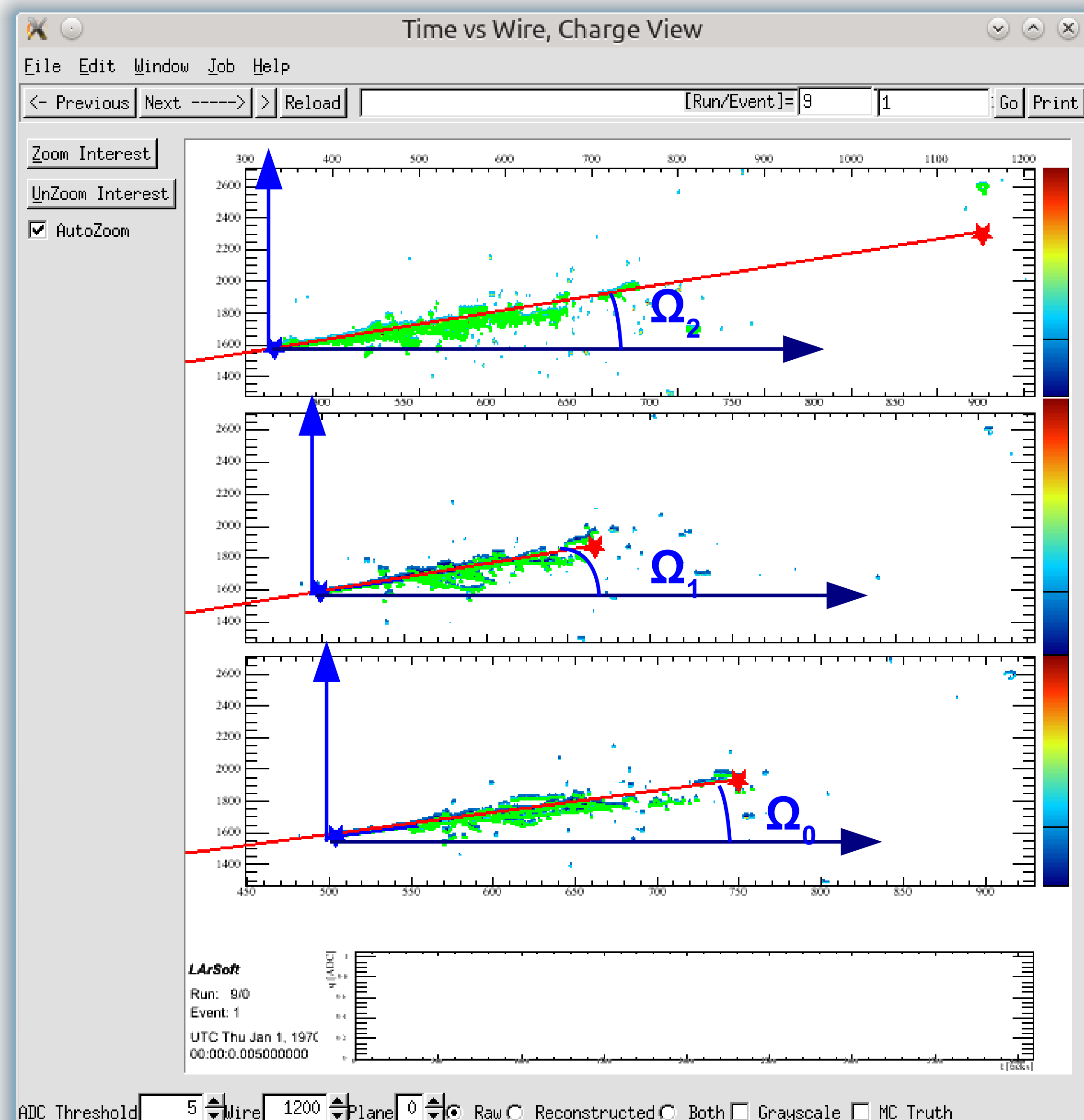
ShowerReco package

- Started by B. Rossi, who has now left Bern
- Reconstructed 3D angles of showers and calculated De/Dx of initial 5cm (arbitrary).
- Worked for ArgoNeut geometry only.
- The version in the repositories worked only for shower events (not connected to shower or shower start finding).

What a shower looks like:

(from the reconstruction perspective)



What you work with are 2D angles from each view. To get those precisely you need the starting point.

Having those you can reconstruct the 3D angles of the shower direction.

3 plane (and 2 plane) geometry

- The code uses the 2D angles (Ω) in 2 views, to reconstruct the 3D angle of the shower.
- Need 2D angles and start pos.

$$\phi = \arctan(n/l)$$

$$\theta = \arccos \frac{m}{\sqrt{(l^2 + m^2 + n^2)}}$$

2 Planes

$$l = 1$$

$$m = \frac{1}{2\sin\alpha}\left(\frac{1}{\Omega_0} - \frac{1}{\Omega_1}\right)$$

$$n = \frac{1}{2\cos\alpha}\left(\frac{1}{\Omega_0} + \frac{1}{\Omega_1}\right)$$

Alpha_0 = 0 if one
of the two planes is vertical
otherwise it is the smaller
of the two

l,m,n are basically the x,y,z
Coords, respectively.

3 Planes

$$l = 1$$

$$m = \frac{1}{2\sin\alpha_1}\left(\frac{\cos\alpha_1}{\Omega_0 \cos\alpha_0} - \frac{1}{\Omega_1} + sgn(!\alpha_0)\left(\frac{\cos\alpha_1}{\Omega_0} - \frac{1}{\Omega_1}\right)\right)$$

$$n = \frac{1}{2\cos\alpha_0}\left(\frac{1}{\Omega_0} + \frac{1}{\Omega_1} + sgn(!\alpha_0)\left(\frac{1}{\Omega_0} - \frac{1}{\Omega_1}\right)\right)$$

ShowerReco: principle of operation

- Once you have the 3D angles you calculate the effective pitch for a given shower-cluster and plane.
- This allows you to calculate the energy deposited per cm of 3d track using Hits from one view only (usually Collection)
- You could then apply the Birks correction and have De/Dx in MeV.

What's new since the last time:

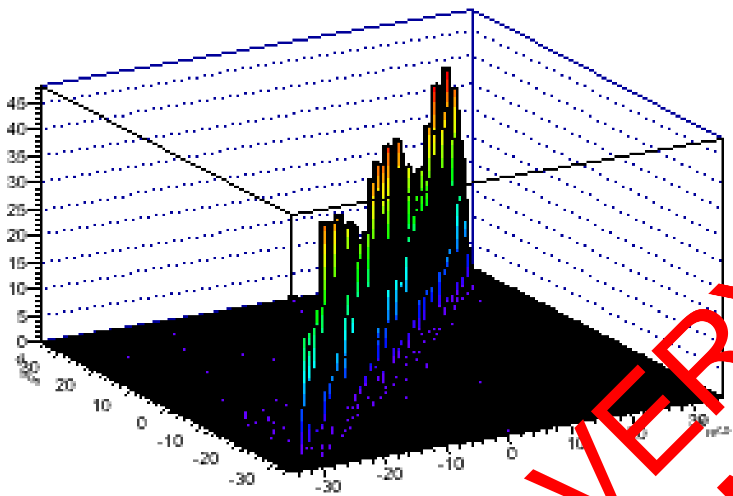
- Most of the work on ShowerAngleCluster – improved and tuned the start finding → each cluster is put into a roughly binned 2D histo, which gives a first guess on the 2D angle and suggests the best planes to fit (Correlation Factor seems to work).
- Both ShowerAngleCluster and ShowerReco now work, after the Geometry and sampling time chanes for uboone (although there is still some work to do, to root out lingering numeric constants)
- Some problems with the start finding were due to Clustering algorithms – ClusterCheater is too good and DBCluster saves showers with spaces in them as separate clusters. Currently there is a workaround implemented but this will work only for single showers..
- For the time being using DBCluster and merging all clusters larger than 15 Hits.

What it currently does:

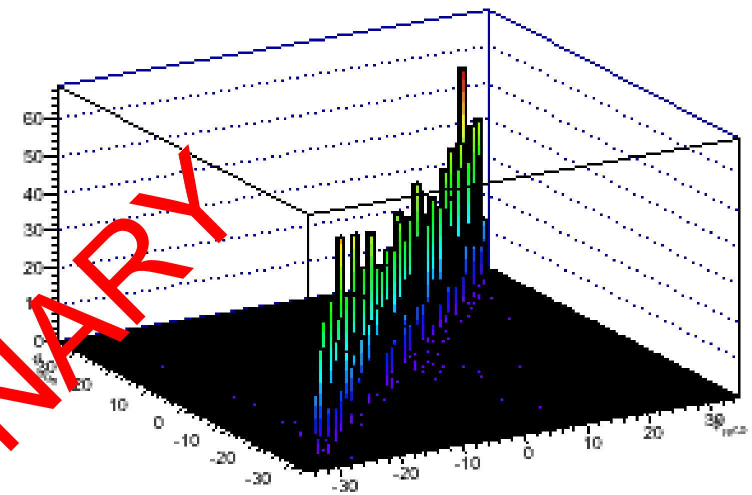
- The ShowerAngleCluster + ShowerReco works on single EM showers that you feed to it (singlegen)
- Generated 10k e-/gamma events for uBooNE (0.5-5.5 GeV) and ArgoNeut (0.1-2.1 GeV) geometries. All events forward going +/-30 degs YZ and XZ.
- Finds the start and 2D angles and reconstructs the 3D angles fairly well.
- Calculates a charge value for the first couple of cm's and saves the first 30cms of hits in a vector – can be used for optimization studies.

Angle Reconstruction: uBooNE (1)

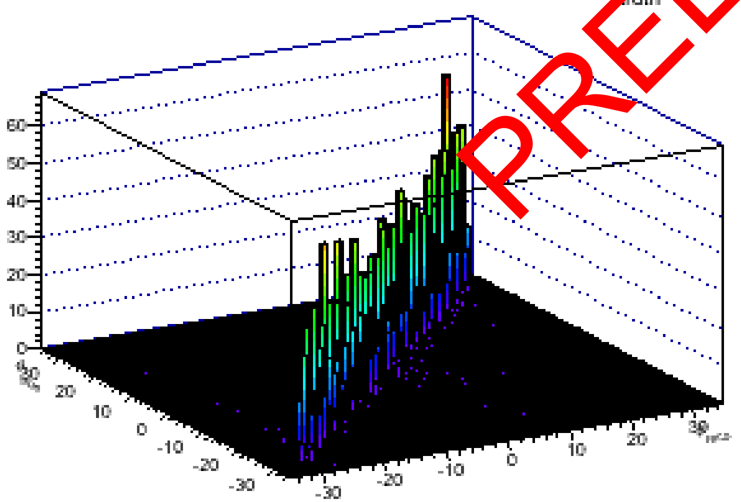
ϕ reconstructed using planes 0&1 vs ϕ_{truth}



ϕ reconstructed using planes 0&2 vs ϕ_{truth}

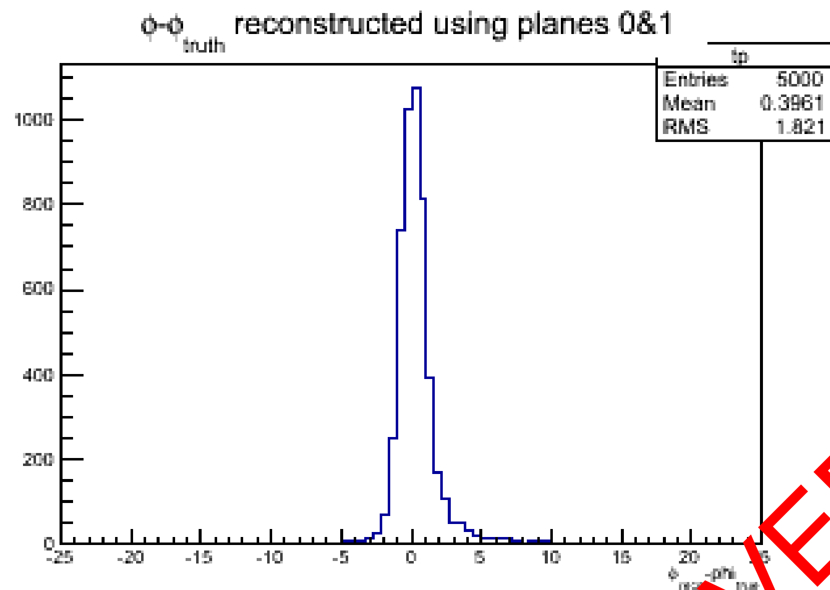


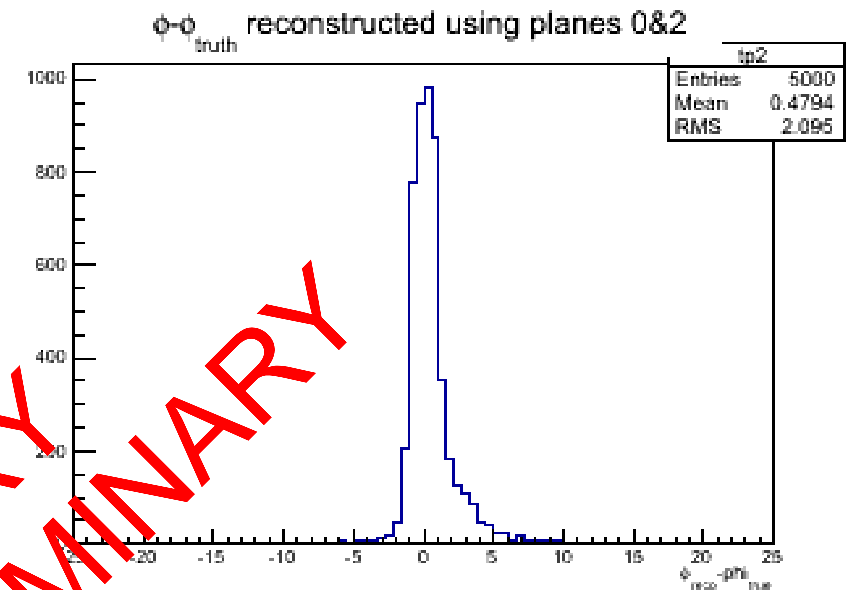
ϕ reconstructed using planes 1&2 vs ϕ_{truth}

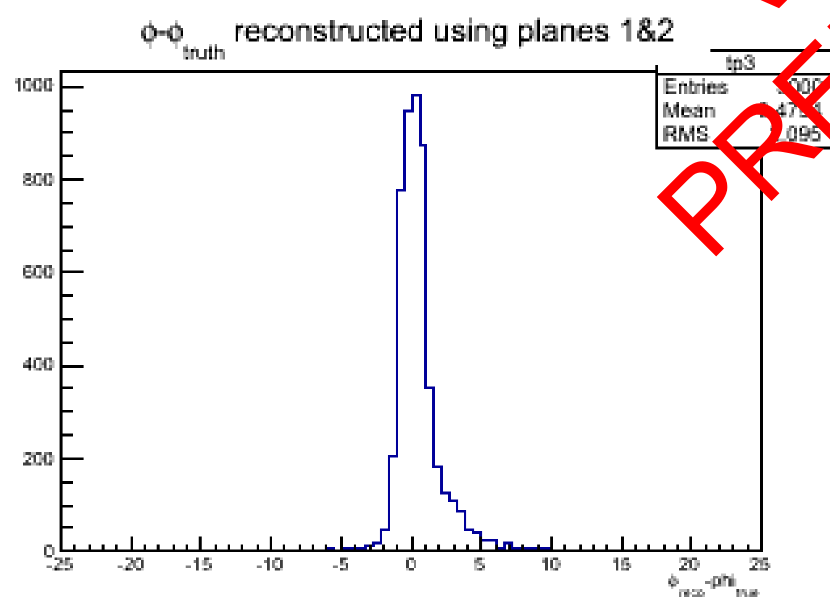


VERY PRELIMINARY

Angle Reconstruction: uBooNE (2)



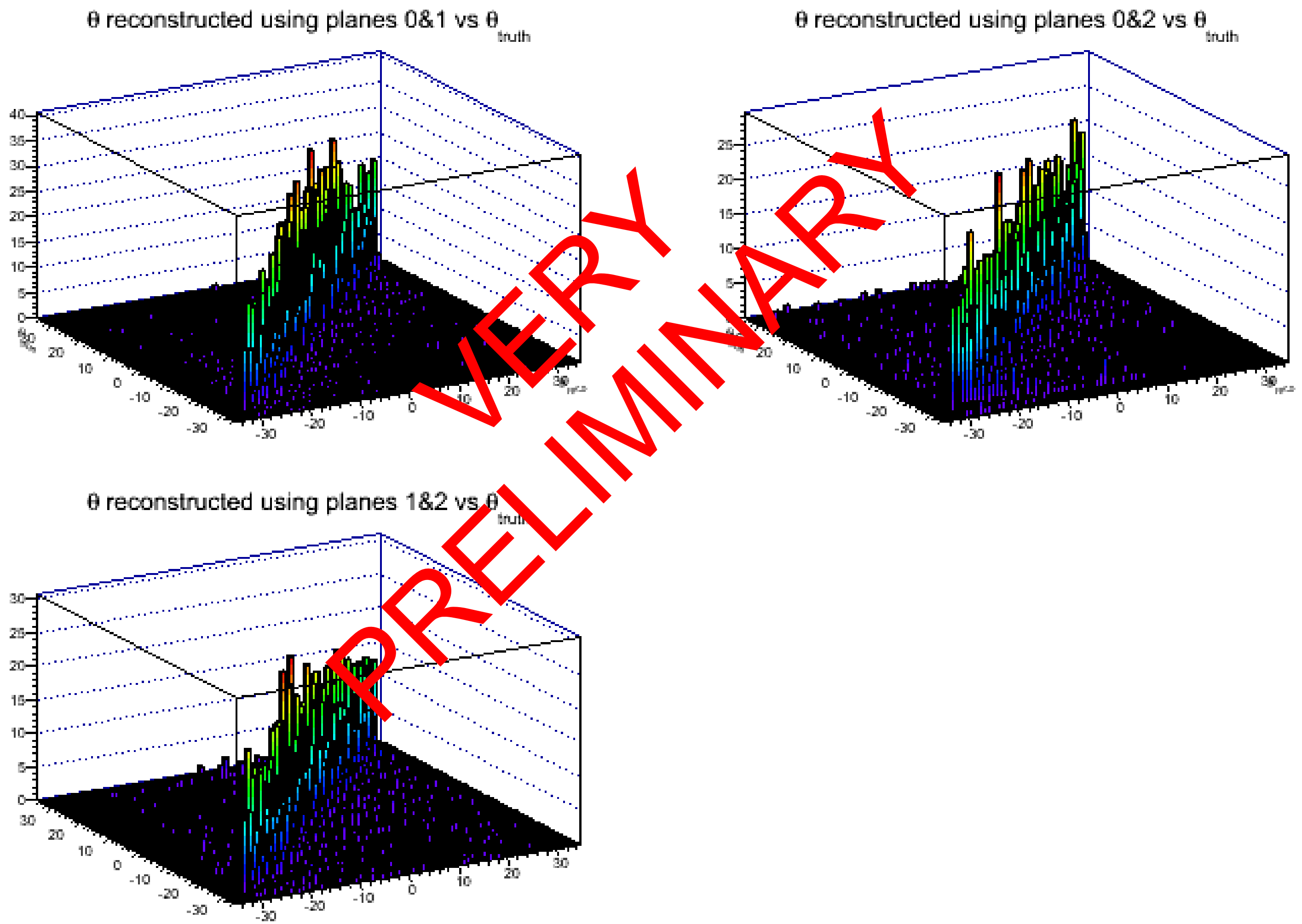




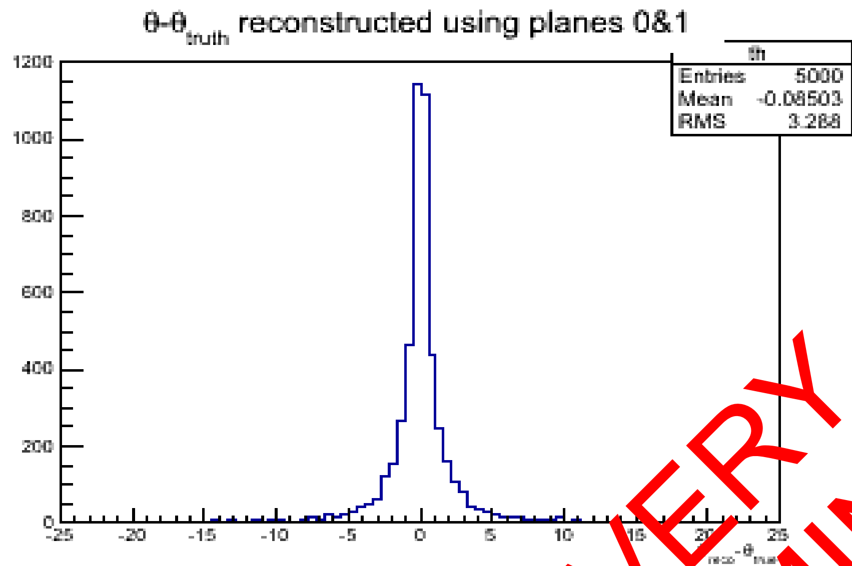
VERY PRELIMINARY

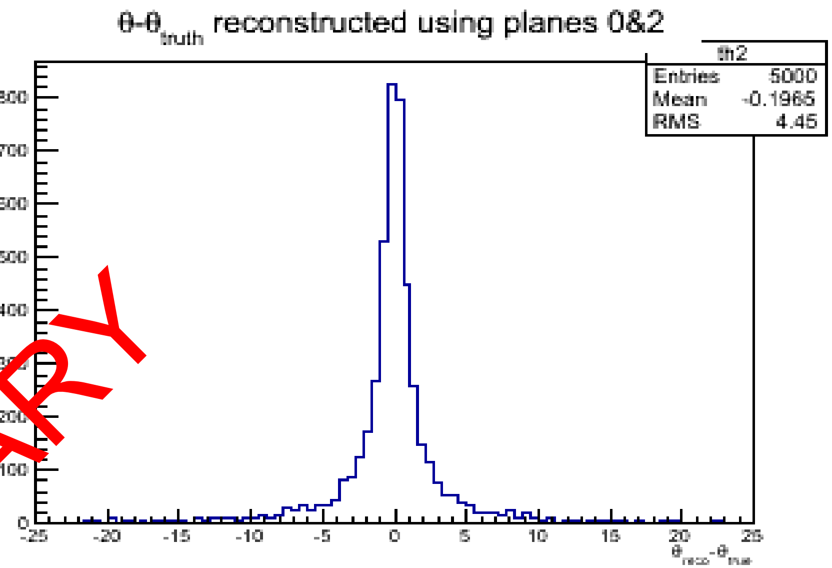
Need to understand the +0.5 deg systematic shift.

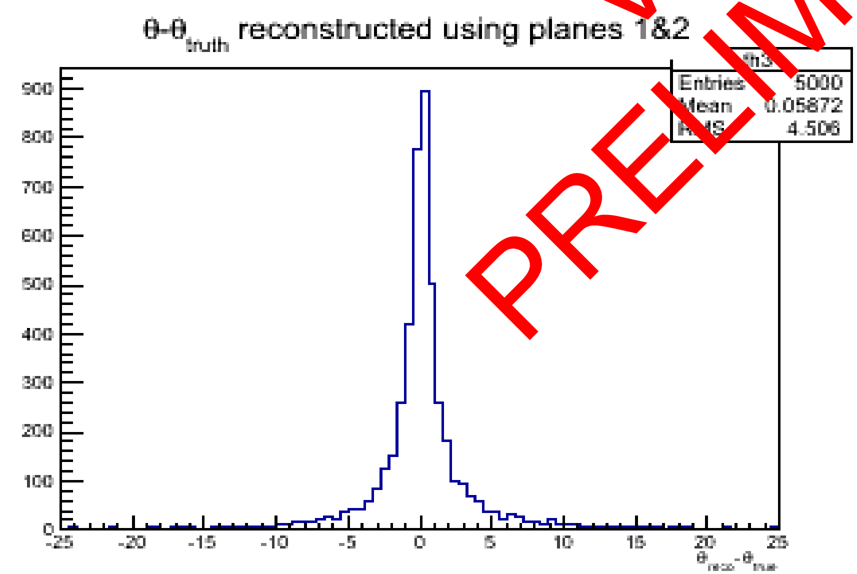
Angle Reconstruction: uBooNE (3)



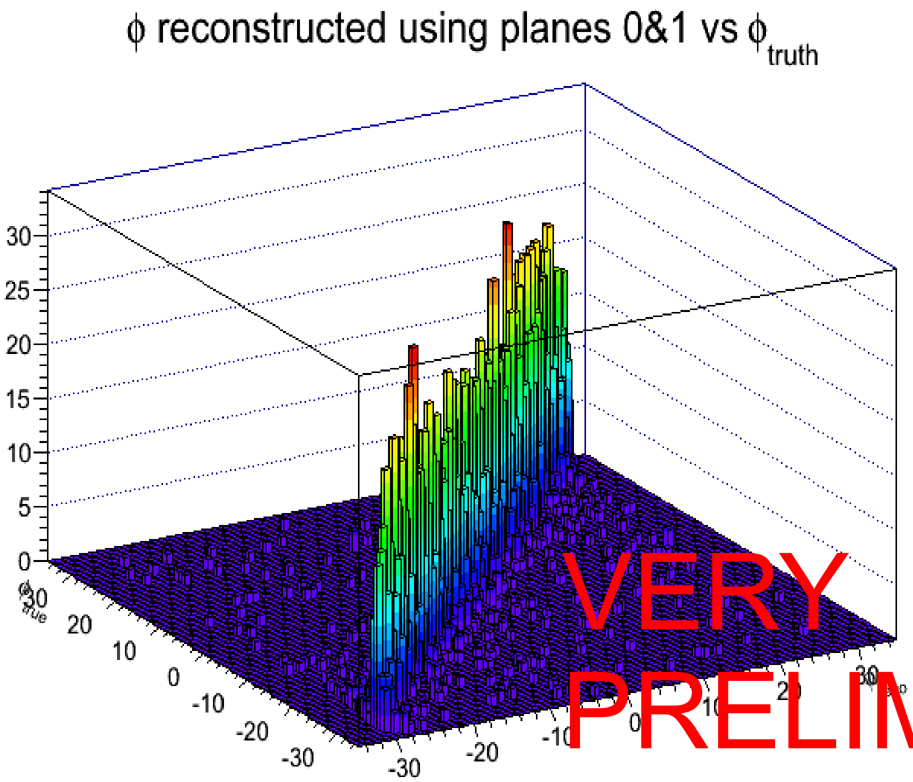
Angle Reconstruction: uBooNE (4)



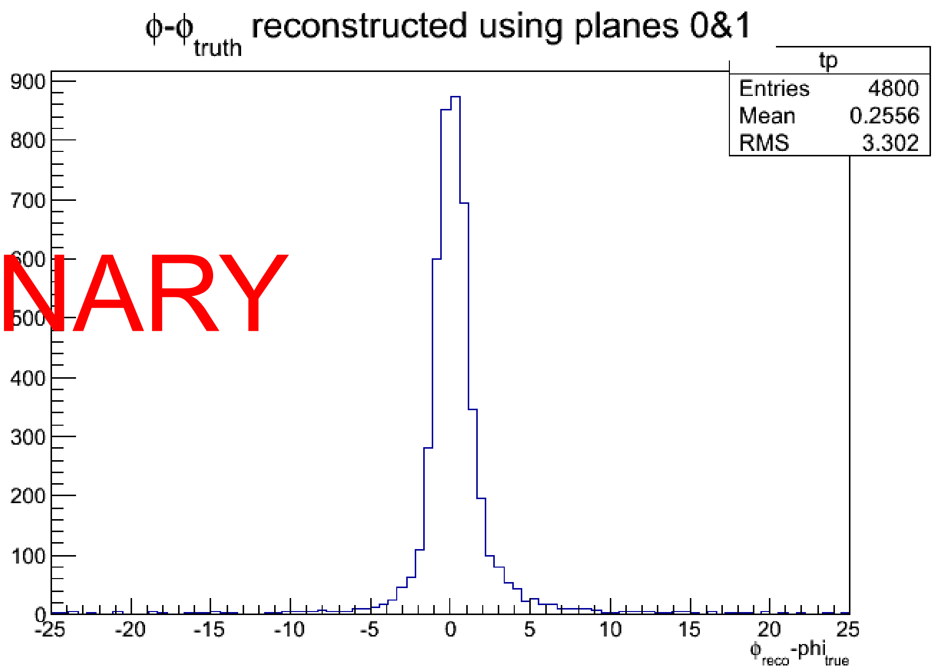




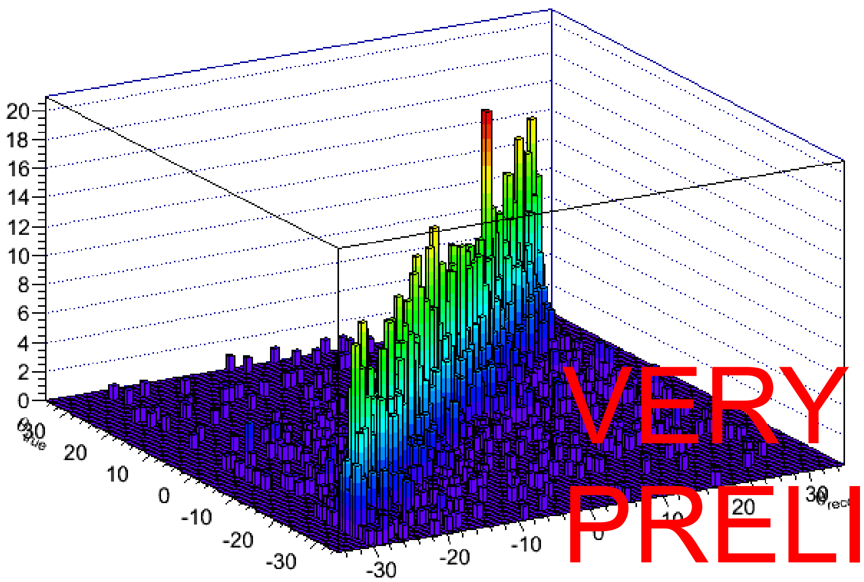
Angle Reconstruction: ArgoNeut (1)



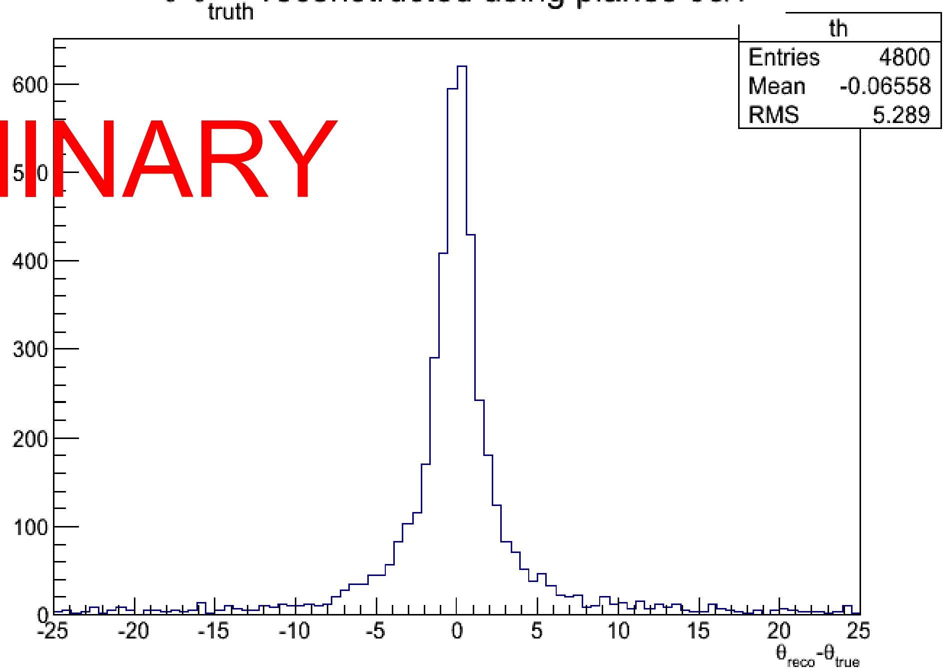
VERY PRELIMINARY



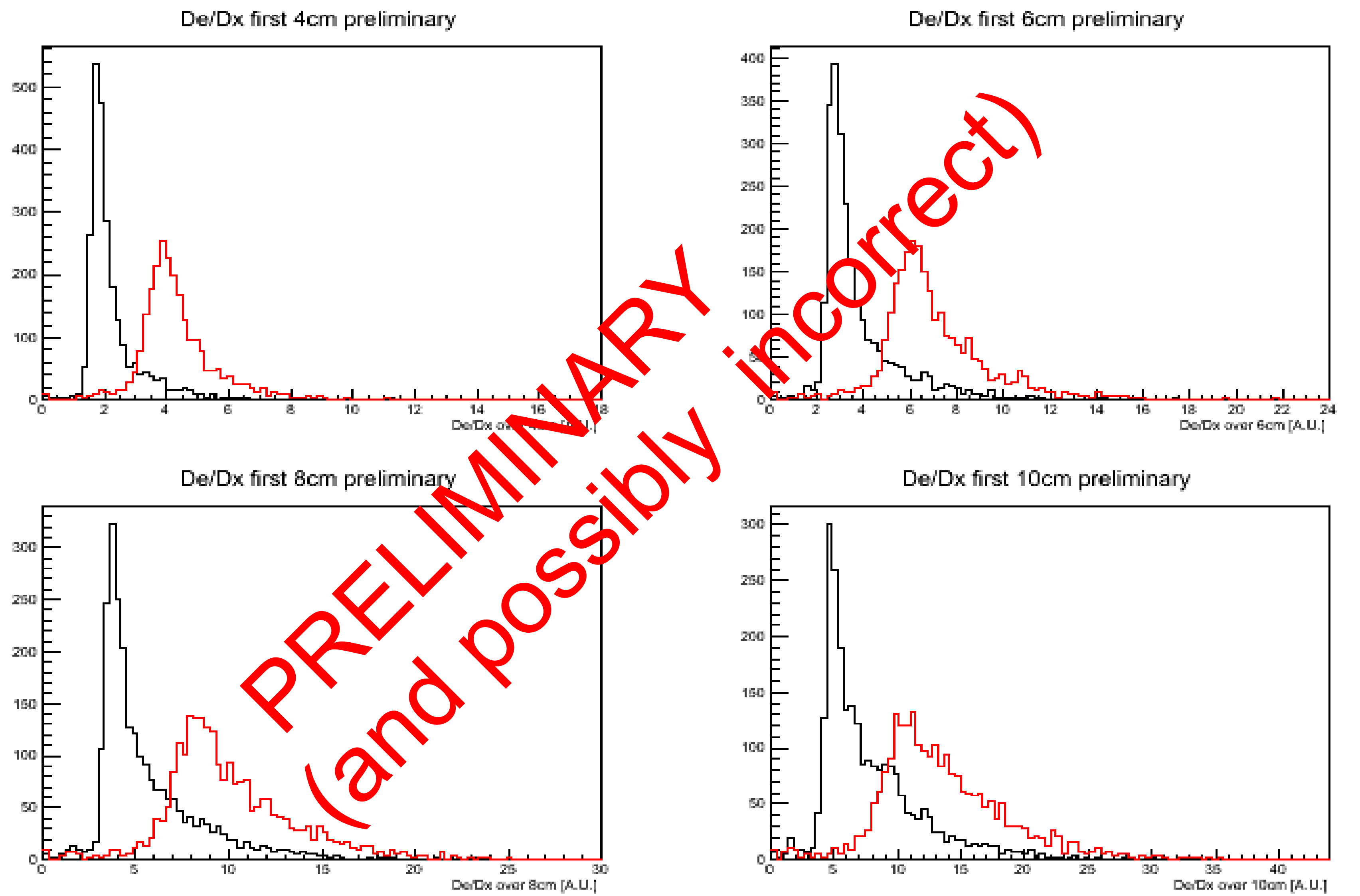
Angle Reconstruction: ArgoNeut (2)



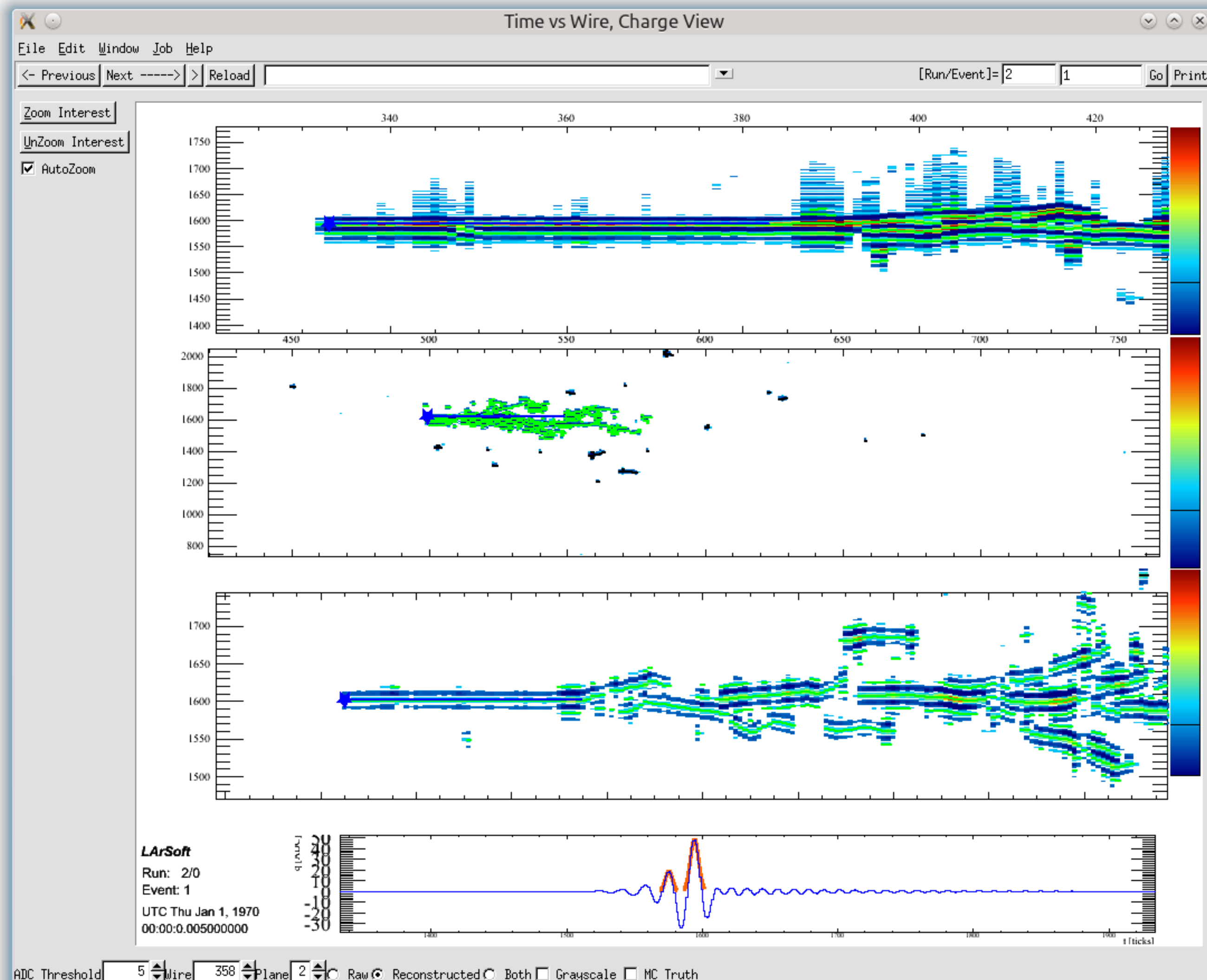
VERY PRELIMINARY



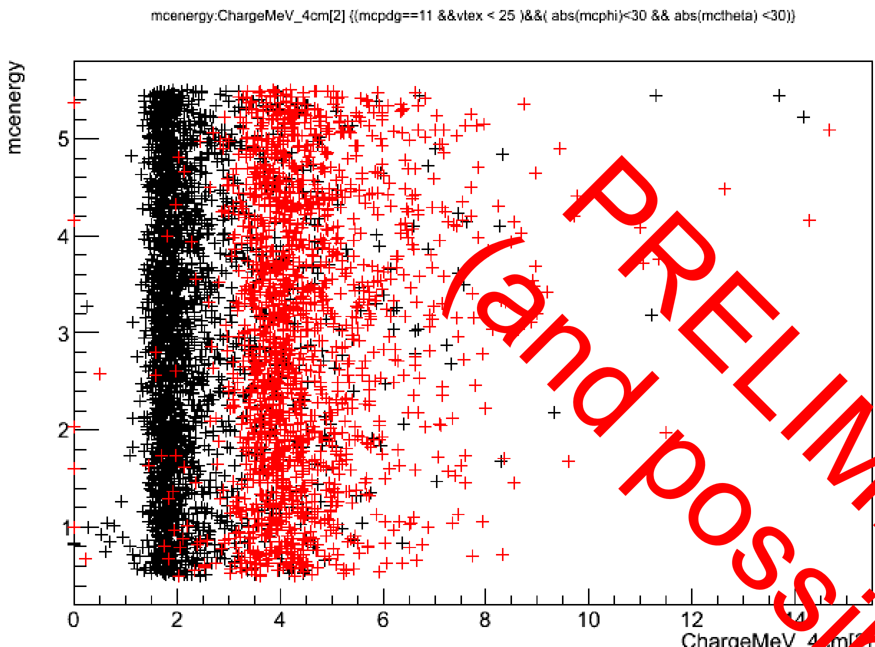
Preliminary De/Dx separation: uBooNE (1)



Why the previous plots are not correct
(but show that the principle works)



Preliminary De/Dx separation: uBooNE (2)

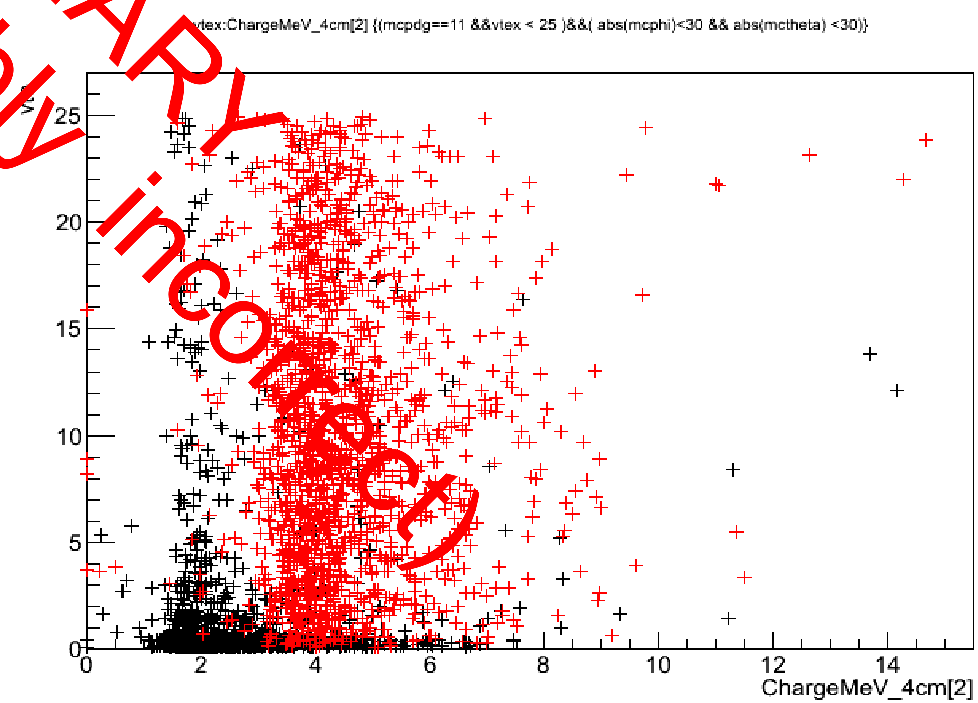


De/Dx in the first 4cm vs MC energy. The separation doesn't seem to be affected very much by energy.

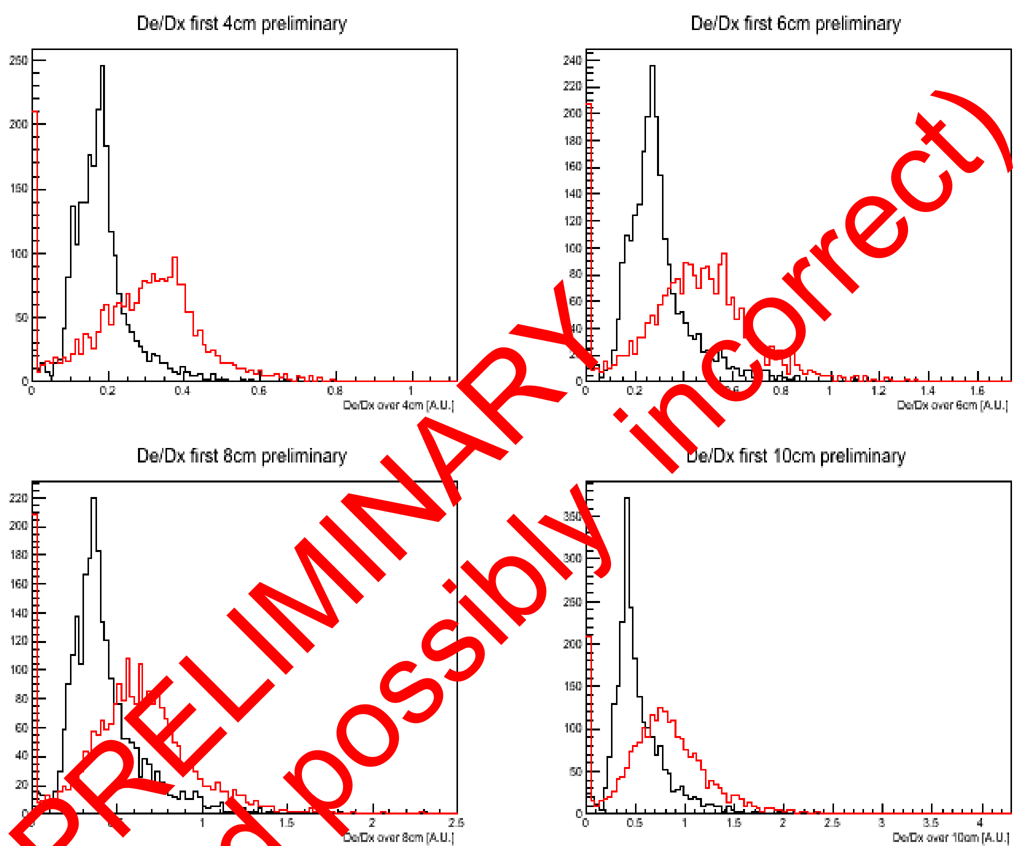
PRELIMINARY
(and possibly incorrect)

Adding other variables will strongly boost particle PID. Distance from vertex is one of the strongest variables (if real vertex is known)

Some electron events still have a misreconstructed vertex → need to debug.



Preliminary De/Dx separation: ArgoNeut (1)

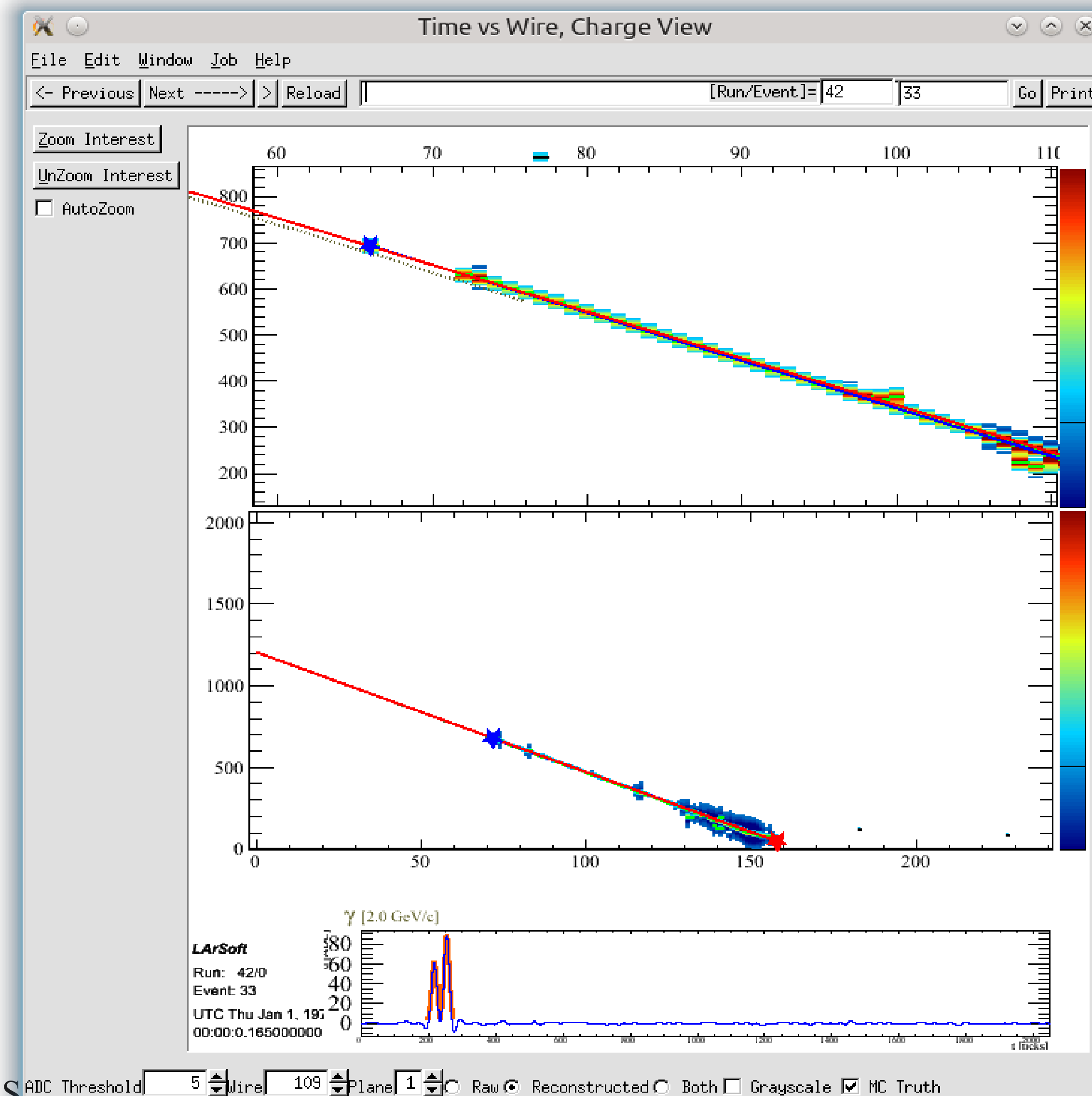


PRELIMINARY
(and possibly incorrect)

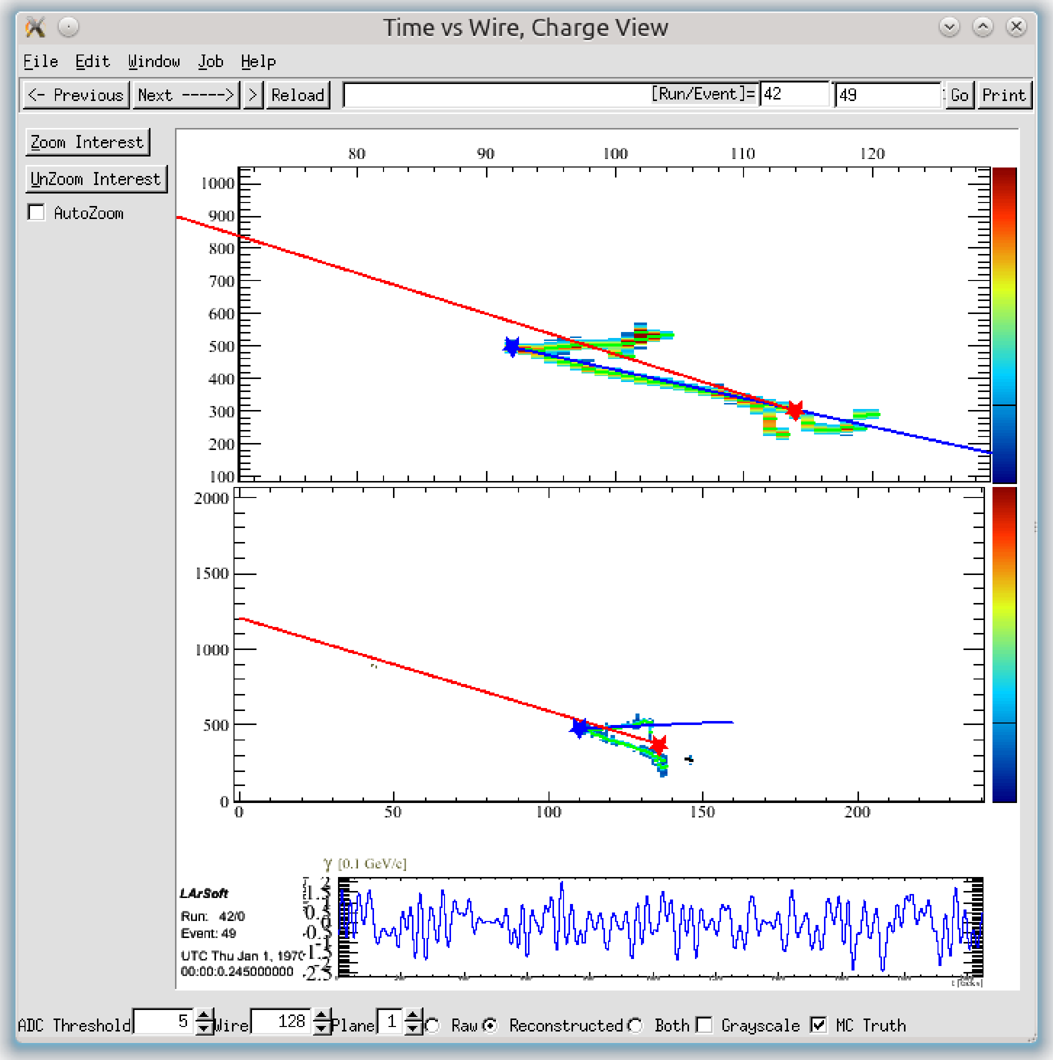
Zero events are often gammas that do not deposit energy in the chamber. Needs better catching in the code.

ArgoNeut DeDx problems:

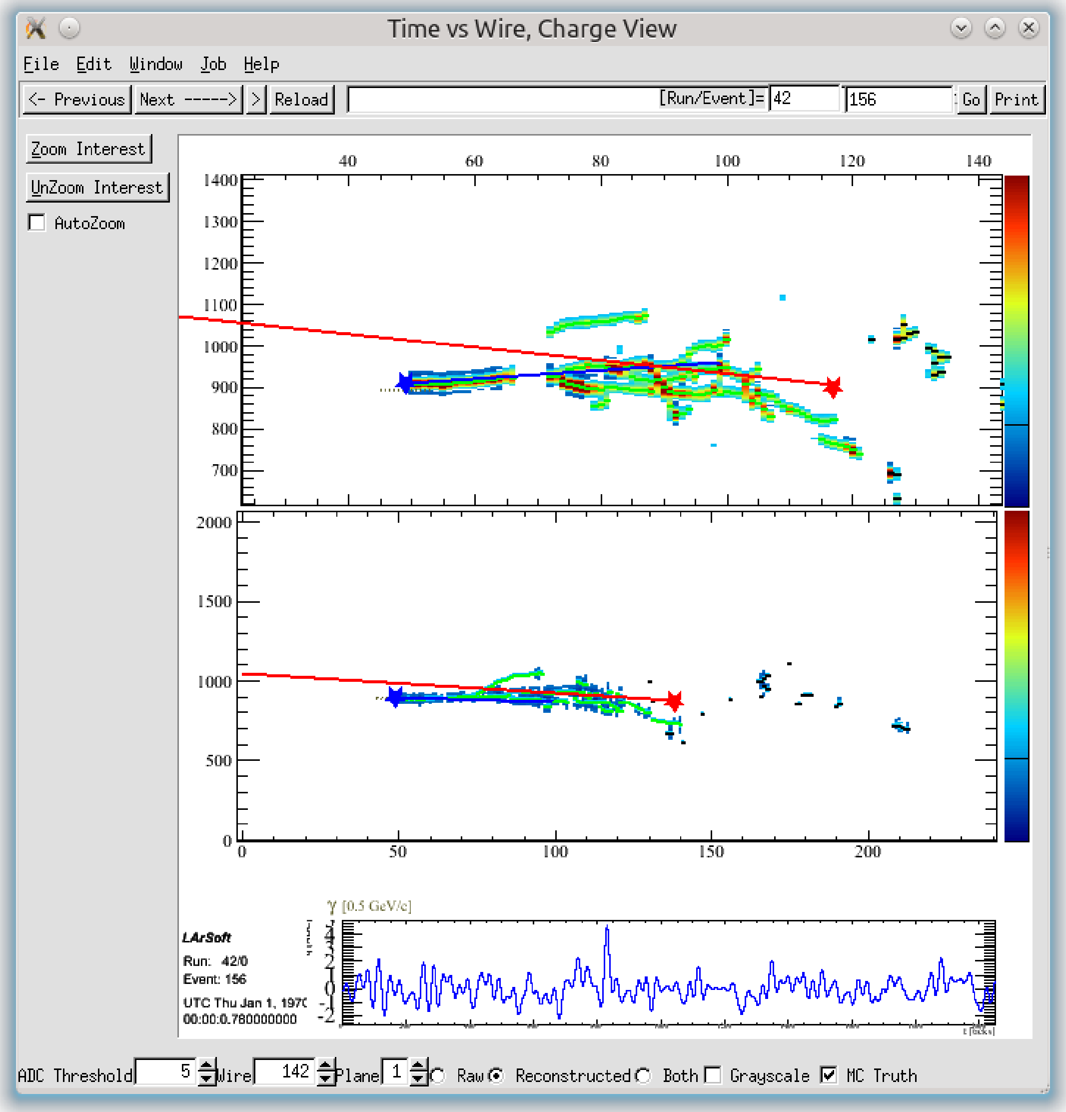
Still a lot of debugging to do, but some events are pretty obvious:



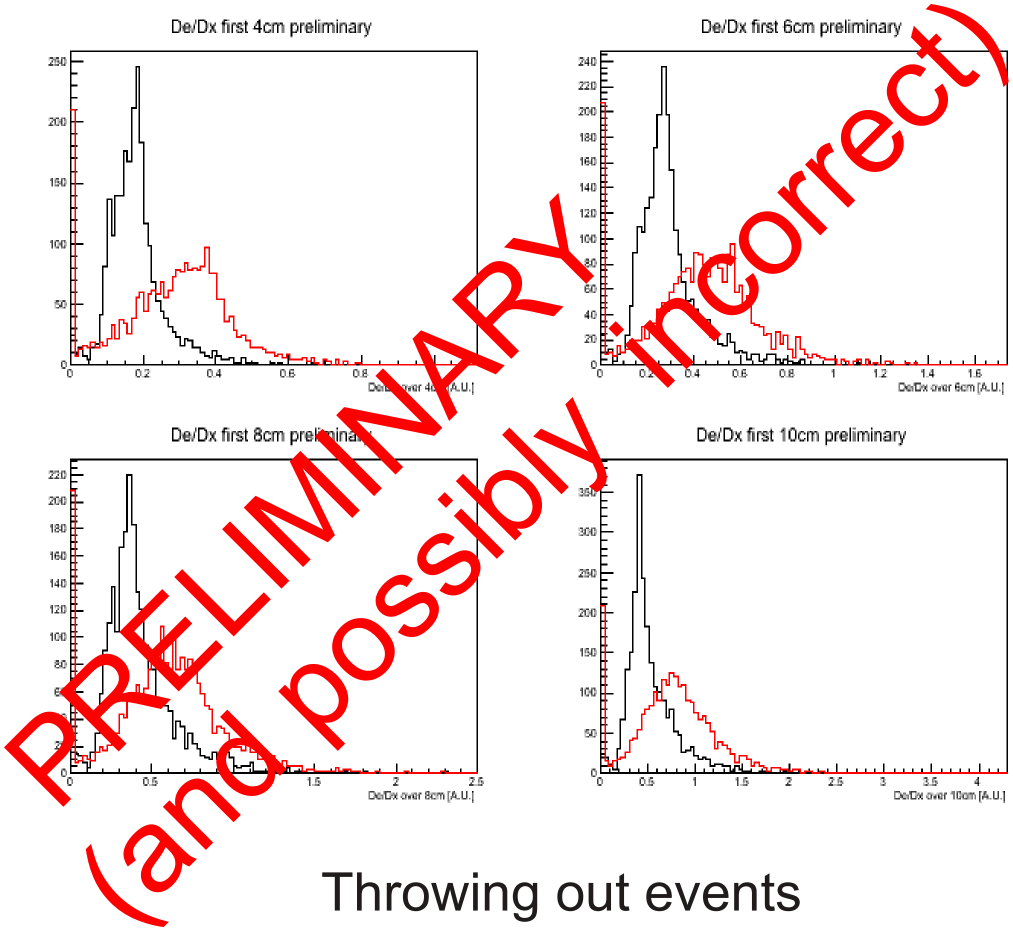
ArgoNeut DeDx problems:



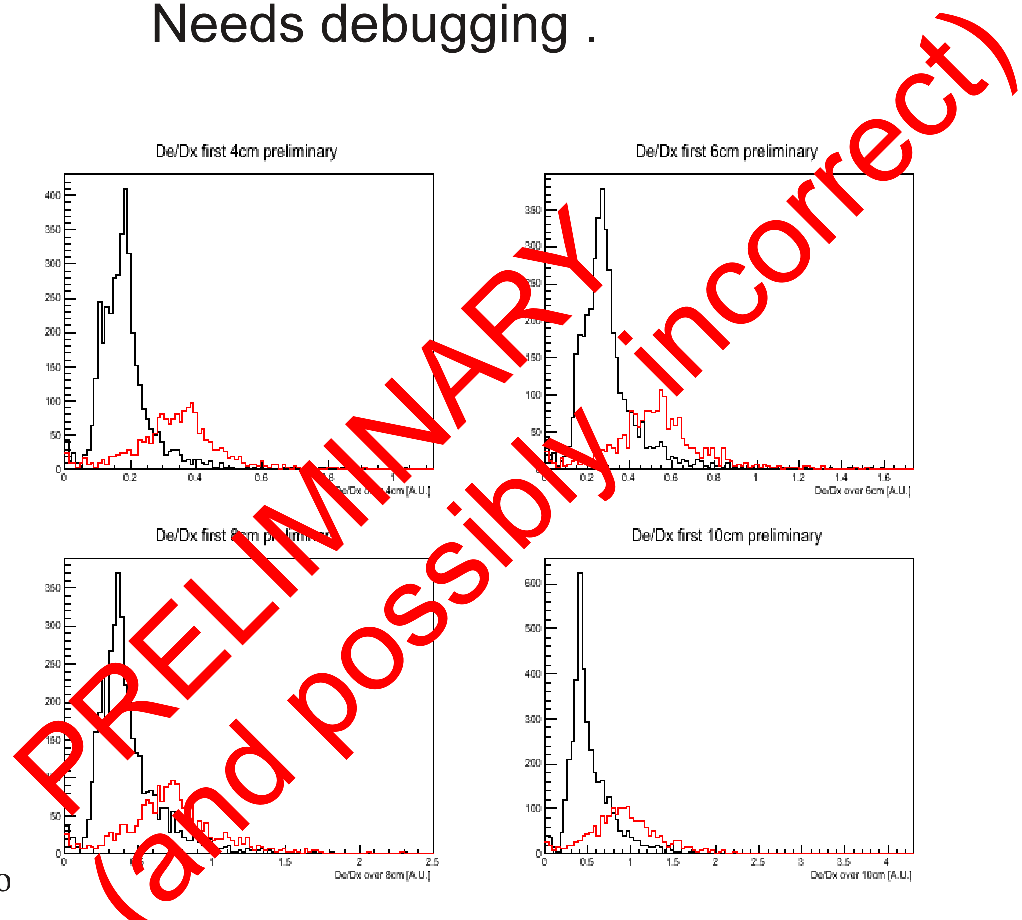
ArgoNeut DeDx problems:



Preliminary De/Dx separation: ArgoNeut (1)



Zero events are often gammas that do not deposit energy in the chamber. Needs debugging .

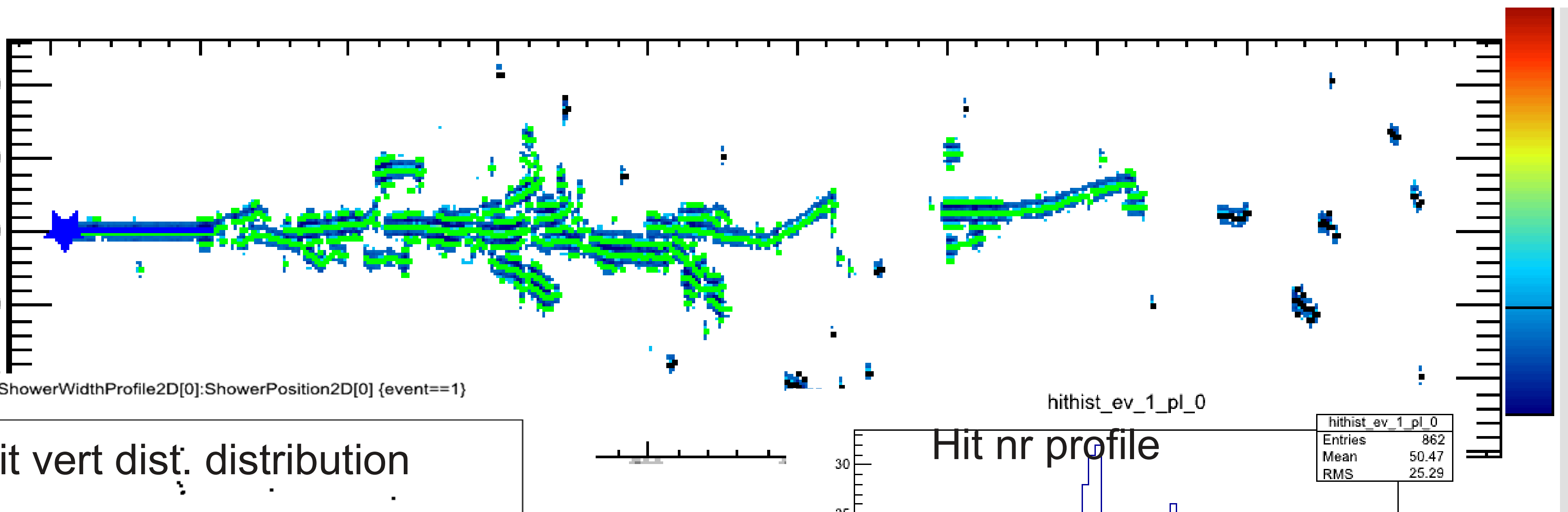


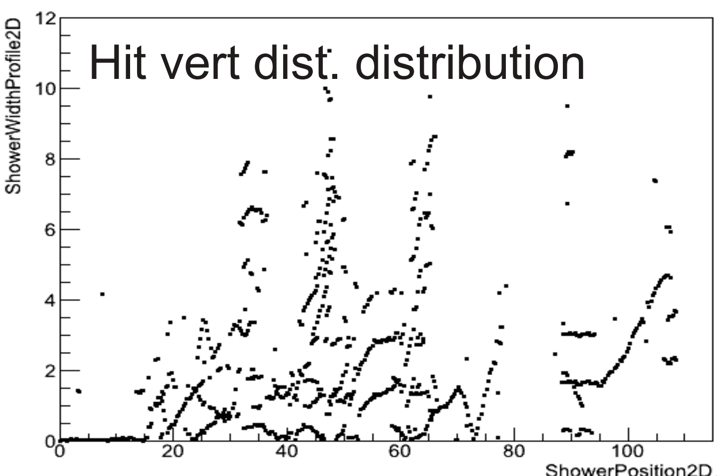
Throwing out events around the missing wires:

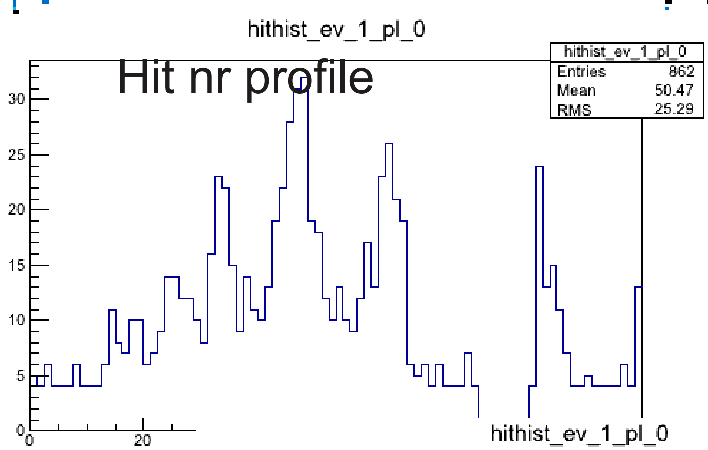
What it doesn't do

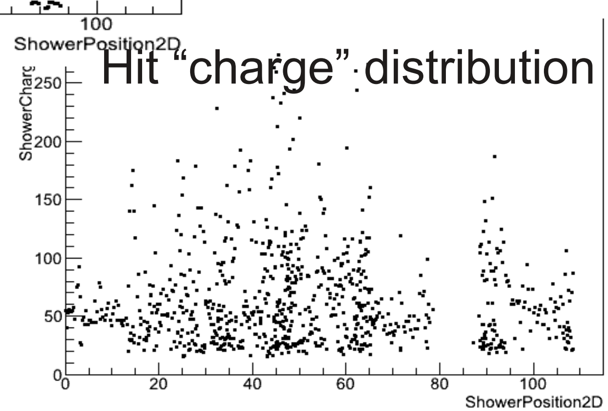
- Work with more than one shower. Need to sort out clustering and then match the clusters with each other.
- Know whether it's looking at a shower or not.
- Work on backwards going showers.
- Work for events parallel to the wire planes (Phi=0)
- Select the best pair of views to use for the reconstruction.
- Catch bad starting points (i.e. time mismatch between views)
- Create a sensible 3D object.
- Work with the wire gap.

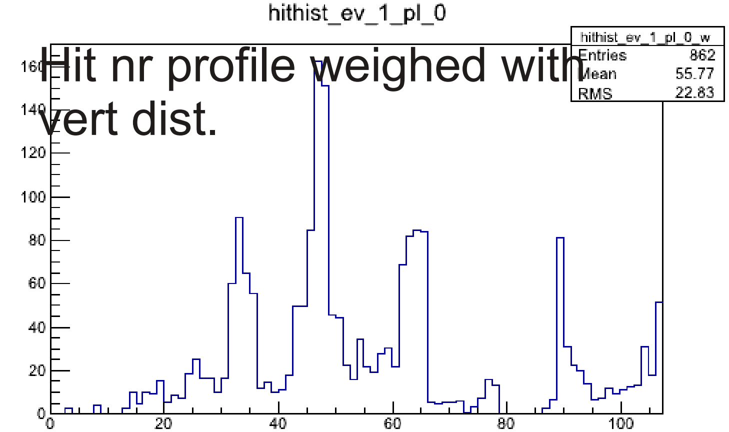
Shower direction and ID ideas:











What's next on the list

- Debug badly reconstructed events.
- Quantize the 2D cluster fit quality and transfer it to ShowerReco. Including catching bad starting points.
- Try to find a way to know if a cluster is “showery” or rather a track. This can also help in understanding which way the shower goes (still at the level of single particles).
- try to find a way to assign 2D shower clusters to each other if there are more showers than one.
- ShowerReco: find formulas/algorithm for phi~0
- Clean up code – branch out *ana modules.
- Add more shower describing variables – improving pid, i.e. charge RMS of primary track, shower width, length etc. Optimize De/Dx calculation length.
- Test on high energy PI naughts?